HEATHKIT "SENECA" AMATEUR TRANSMITTER
MODEL VHF-1

SPECIFICATIONS

Power Input:	6 meters 140 watts CW, 120 watts Phone (peak) 2 meters 110 watts CW, 95 watts Phone (peak)
Output Impedance:	50-72 Ω (non-reactive)
Output Coupling:	Link (coaxial)
Operation:	Crystal-VFO, CW-Phone
Band Coverage:	50-54 MC, 144-148.3 MC
Audio:	Screen modulated, controlled carrier
Tube Complement:	5R4GY HV rectifier 5V4G LV rectifier OA2 voltage regulator 12AX7 speech amplifier 6DE7 modulator, carrier control 6AU6 VFO 6AN8 crystal oscillator-multiplier 2E26 driver 2-6146 push-pull power amplifier 6AQ5 clamp
Power Requirements:	117 volts AC, 60 cycles
Standby (phone, CW):	120 watts
Full load (phone, CW):	400 watts (intermittent)
Cabinet Size:	16 5/8" wide x 10 1/8" high x 10" deep
Net Weight:	50 lbs.
Shipping Weight:	62 lbs.

INTRODUCTION

The Heathkit Model VHF-1 "Seneca" Transmitter was designed to extend the transmitting complement of the amateur radio station into the VHF region. It features up to 120 watts input on phone and 140 watts input on CW in the 6-meter band. In the 2-meter band, these ratings are reduced slightly to prolong final amplifier tube life. It includes controlled carrier phone operation, has built-in VFO for both 6 and 2 meters, and four switch-selected crystal positions. Panel controls allow VFO or crystal control, phone or CW operation on both amateur bands.

The "Seneca" consists of two power supplies, five radio frequency stages, and two dual-triode audio stages. A pair of 6146's, operating push-pull in the final amplifier, uses quarter wave tuned lines or a split-tank inductor, with a tunable link output coupling for 50 or 72 Ω transmission line.

Complete RF shielding from the VFO circuit to the final amplifier is incorporated in this Transmitter. Feed-through type bypass capacitors are used on all power leads entering the RF compartments for greater TVI protection and transmitter stability.

The front panel controls consist of an Xtal-VFO switch, meter switch, two antenna loading controls (antenna tuning and antenna coupling), buffer tuning, multiplier tuning, driver tuning, final amplifier tuning, function switch, band switch, VFO tuning, and a spotting push button switch. The VFO slide rule type dial is edge illuminated and with vernier tuning provides ample bandspread and accurate frequency settings.

The mike connector, output connector, key jack, and auxiliary socket are located on the rear chassis apron. The auxiliary socket is so connected to allow remote control of the Transmitter such as using voice control with a Heathkit Voice Control Unit, and also has connections for receiver muting and for operating an antenna relay.

The following block diagram and circuit description will give the builder a better understanding of the Transmitter. This knowledge is an invaluable aid to construction and as such, is well worth reading thoroughly.

IN A TRANSMITTER OF THIS SIZE, LETHAL VOLTAGES ARE PRESENT. CONSEQUENTLY, GREAT CARE MUST BE EXERCISED WHEN ANY TESTS OR ADJUSTMENTS ARE MADE.

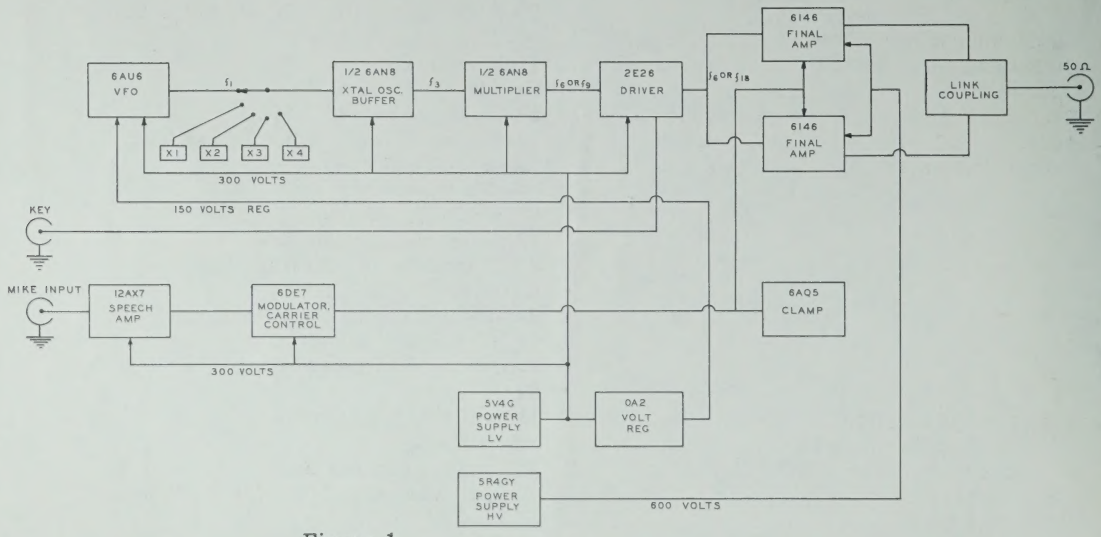


Figure 1

VFO

The VFO circuit consists of a 6AU6 tube operating as a Clapp oscillator in the frequency ranges of 8.000 to 8.222 mc and 8.333 to 9.000 mc. Undue heating effects are prevented by mounting the tube on top and outside of the VFO enclosure. Also, the VFO subchassis is located away from all other heat generating components in the final assembly to further decrease heating effects upon the enclosure. A double bearing ceramic insulated dual tuning capacitor is used as the frequency control. The dual capacitor, consisting of two stator assemblies of different capacity, permits a large bandspread on both bands. Two ceramic insulated air trimmers for bandspread adjustment prevent initial drift during calibration.

The VFO frequency determining coil (L-1) is wound on a heavy ceramic slug-tuned form, heavily doped and baked. This combination achieves high-Q, low drift, and decreases the effect of humidity. A temperature compensating capacitor (C-1) of the negative type is mounted in close proximity to the coil. Thus, a rise in temperature of the coil will increase the inductance, and this same temperature rise will decrease the capacity of the temperature compensating capacitor. By properly proportioning these components, the effects of one cancel the other and the frequency remains constant with a change in temperature.

The VFO switch has solid coin silver contacts for minimum of contact resistance and long life. It is operated by a linkage mechanism on the band switch, which correlates the VFO output frequency with the band in use.

The Clapp or series-tuned Colpitts oscillator circuit is a high-Q circuit obtained by tapping the tube across only a small portion of the oscillating tank circuit, resulting in very loose coupling between tube and circuit. Three capacitors connected in series across the coil (consisting of the two large fixed value capacitors (C-3, C-4) and the tuning capacitor with their respective padding capacitors in parallel) provide the taps across which the tube is connected. These large capacitances also lessen the effect of input tube capacitance upon frequency. The 6AU6 tube essentially operates as an electron-coupled oscillator with the tube's screen grid as the oscillator plate. The screen grid voltage is stabilized at 150 volts by an OA2 regulator in the power supply. With the screen grid operating as the oscillator plate, the actual tube plate is coupled to the oscillator only by the electron stream in the tube and is further shielded from the oscillator by the grounded suppressor grid. This effectively isolates the oscillator circuit from the following stages and lessens the effect of loading on the VFO frequency.

The output of the VFO is also band switched between two slug-tuned coils (L-2 and L-3), tuned with the distributed capacity of the coaxial cable which is fed to one position of the Xtal-VFO switch in the multiplier subchassis. A 47 Ω resistor (R-2), in series with the output coils, broadens the circuit and therefore the RF output voltage from one end to the other of both bands is fairly constant in amplitude.

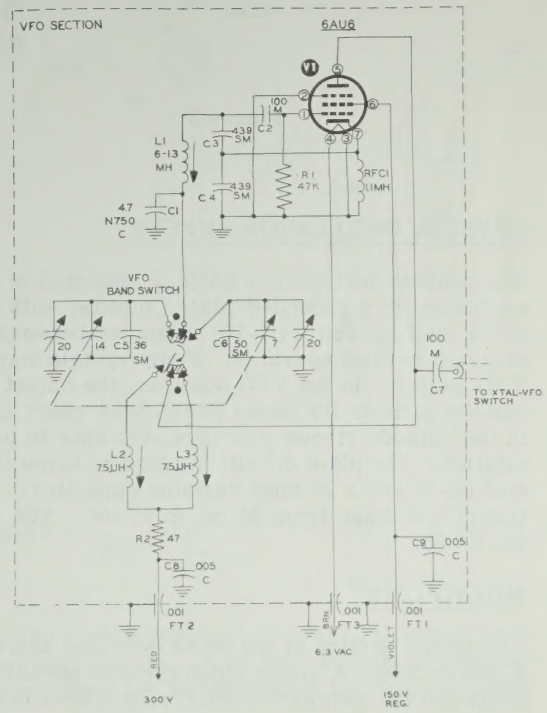


Figure 2

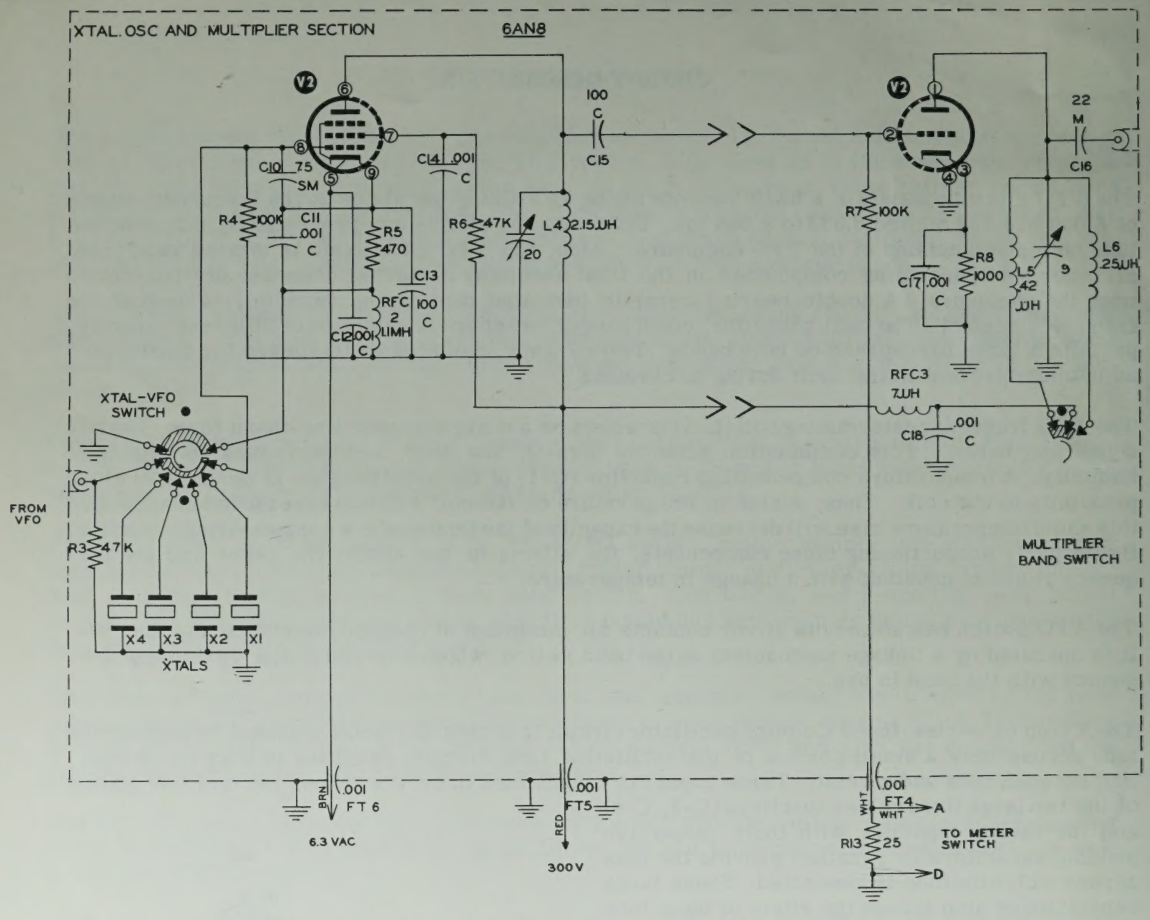


Figure 3

Figure 4

CRYSTAL OSCILLATOR-BUFFER

The pentode section of a 6AN8 is operated in a tuned-plate circuit, the oscillating circuit being equivalent to a grounded-plate Colpitts, with the crystals connected between grid and ground. A 7.5 mmf capacitor (C-10) connected between grid and cathode increases excitation and prevents sluggish crystal operation. Four crystals may be switched into the circuit by means of the Xtal-VFO switch. In the VFO position, the output of the VFO is connected between grid and ground and the cathode RF choke (RFC-2) is short circuited in this position. A 470 Ω resistor (R-5) in the cathode circuit provides self-bias to prevent exceeding plate dissipation with loss of excitation. The plate circuit is tuned to three times the input frequency with an air wound high-Q coil (L-4) and a 20 mmf variable capacitor. The capacitor is brought out to the front panel for tuning this stage from 24 mc to 27 mc. The output is capacity coupled to the triode section of the 6AN8.

MULTIPLIER

The triode section of the 6AN8 operates as a doubler to the 6-meter band and as a tripler for the 2-meter band. A meter shunt resistor (R-13) is permanently connected in the grid circuit of this stage and the meter switched across it when reading drive from the crystal oscillator-buffer stage.

This stage also has self-bias, using a 1 KΩ resistor (R-8) in the cathode circuit. The multiplier switch, which is operated by a linkage mechanism on the band switch, switches the B+ voltage for the plate circuit between two tank coils. With the multiplier switch in the 6-meter position, a 15 mmf variable capacitor, which is brought out to the front panel, tunes the 6-meter tank coil (L-5) from 50 mc to 54 mc. In the 2-meter position, the same 15 mmf variable capacitor tunes the 2-meter tank coil (L-6) from 72 mc to 74.15 mc. An RF choke (RFC-3), in series with the tank coils, prevents RF from feeding back into the B+ line. The output of this stage is capacity coupled to the driver stage through a coaxial cable. Both the crystal oscillator-buffer and second multiplier circuits are completely enclosed for shielding and all leads entering the subchassis assembly are bypassed with feed-through type capacitors.

DRIVER

A 2E26 operates straight through on six meters, and doubles to two meters to drive the final amplifier. As in the preceding stage, grid drive is measured and the stage is self-biased. Cathode keying is employed with the cathode circuit being connected to the key jack. It is also connected to the spotting push button switch and the function switch. Closing the key, depressing the spotting push button switch, or placing the function switch in phone position all complete the cathode circuit to ground to put the stage into operation.

Due to the fact that the driver operates straight through on 6 meters, more than ample drive is provided so it is necessary to reduce this drive to prevent damage to the grids of the final amplifier. This is accomplished by reducing the screen voltage to the 2E26 by means of a voltage divider network, consisting of a 23.5 KΩ resistor (R-11) which is connected in series with a 10 KΩ resistor (R-12) through the driver band switch. With the band switch in the 2-meter position, the 10 KΩ resistor is disconnected and normal screen voltage is applied for maximum output from this stage. By properly proportioning the two values of screen voltages, the drive appearing at the grids of the final amplifier will be approximately the same on both bands.

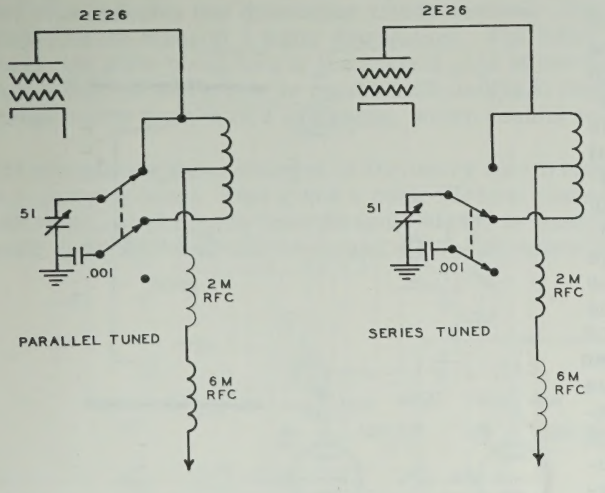


Figure 5

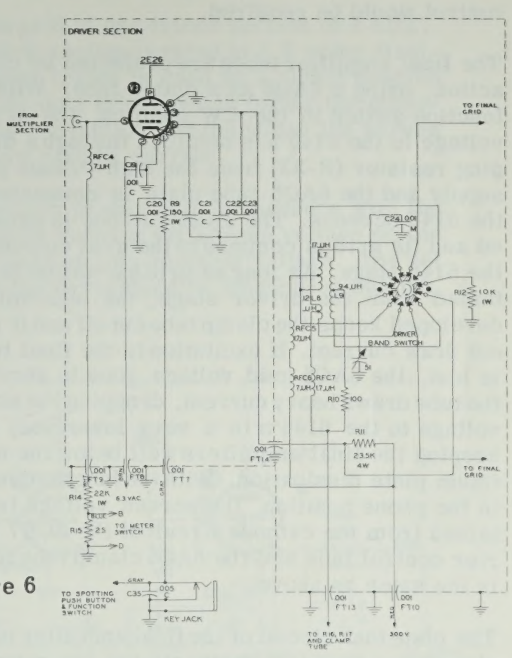


Figure 6

Referring to Figure 5, the plate circuit of the 2E26 is switched from a "parallel tuned" tank circuit on 6 meters to a "series tuned" tank circuit on 2 meters. A 51 mmf variable capacitor tunes this circuit from 50 to 54 mc in the 6-meter band and 144 to 148.3 mc in the 2-meter band.

A 2-meter RF choke (RFC-5) which is connected to the low potential RF point on the tank coil offers high impedance to the 2-meter energy and a 6-meter RF choke (RFC-6) connected in series with the 2-meter RF choke offers high impedance to the 6-meter energy.

The output of the driver stage is transformer coupled to the grids of the final amplifier tubes. This stage is also completely shielded, using feed-through type capacitors for all leads entering the compartment.

FINAL AMPLIFIER

Two 6146 type tubes operate in push-pull in the final amplifier stage which operates straight through on both bands.

The grid circuits are switched between two grid tank coils, one which is tuned to 6 meters (L-9) and the other which is tuned to 2 meters (L-8), using the input capacities of the final tubes. Both coils are mounted on the driver band switch wafer using inductive coupling for maximum energy transfer from the driver stage. In addition, these double tuned circuits help to reject high order oscillator and multiplier harmonics.

Neutralization is employed on both bands for maximum stability of the final amplifiers. The self-neutralizing frequency of the 6146 is in the neighborhood of 100 mc, making a switched neutralization circuit mandatory. With the band switch in the 6-meter position, conventional cross-neutralization is employed, but with the band switch in the 2-meter position, neutralization is accomplished by increasing the effective grid-to-plate capacitance of each tube in order to cancel the screen-lead inductance. With the 6146's operating in the 2-meter band, the screen-lead inductance becomes quite appreciable, allowing a considerable amount of energy leak-through from plate to grid even though the screen is carefully bypassed. Screen neutralization could have been employed, but because of its frequency sensitivity, another operating control would be required.

The final amplifier tubes are protected by clamp action, using a 6AQ5 as a clamp tube. With the function switch in the CW position, the screen voltage to the 6146's is obtained through a dropping resistor (R-32) from the high voltage plate supply and the 6AQ5 tube plate is connected at the 6146 screens. The 6AQ5 cathode is grounded and its grid is common to the grid circuits of the 6146 stage. As long as grid excitation is obtained from the driver stage, the bias voltage developed keeps the clamp tube cut off and it does not draw current. If excitation to the final tubes is lost, the 6AQ5 grid voltage goes to zero and the tube draws heavy current, dropping the screen voltage to the 6146's to a very low value, thus keeping the final amplifiers well below the maximum plate dissipation. With the function switch in the phone position, the screen voltage is obtained from the cathode circuit of the 6DE7 carrier control tube and the 6AQ5 clamp tube action is the same as above.

The plate tank circuit of the final amplifier is enclosed in a separate compartment for complete shielding and to reduce radiation loss from the tuned lines. The plate circuit is composed of a shorted quarter-wave section of transmission line for the 2-meter band. A double ended

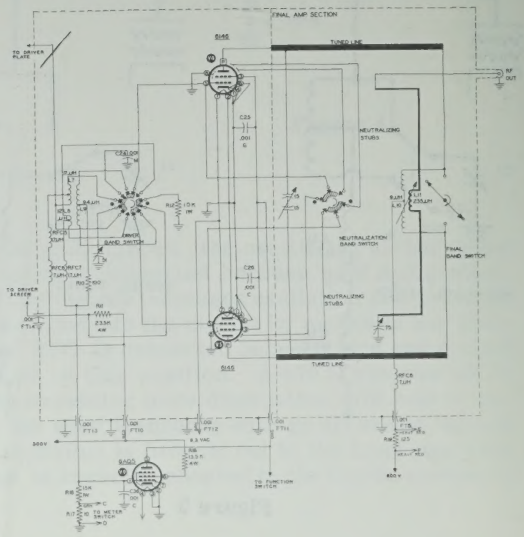


Figure 7

knife action type switch (final band switch) located at the ends of the silver plated tuned lines acts as the shorting bar and is connected to the band switch linkage mechanism. With the band switch in the 6-meter position, the tuned lines are unshorted and merely act as extended plate leads for the 6-meter split tank coil. The 6-meter tank coil also acts as a pair of 2-meter RF chokes connected at the low potential RF point on the tuned lines when operating on 2 meters. The tuned lines and the tank coil are resonated at the tube end by a "butterfly" type variable capacitor. The rotor of the "butterfly" capacitor is left ungrounded to prevent possible stray resonances and parasitic oscillations that may appear higher than the operating frequency.

Quarter-wave tuned lines were chosen over half-wave tuned systems because of the space limitations and also the fact that in push-pull circuits, the third order harmonic is prominent. Thus, a strong third harmonic of 50 megacycle energy from the final amplifier could result using a half-wave system.

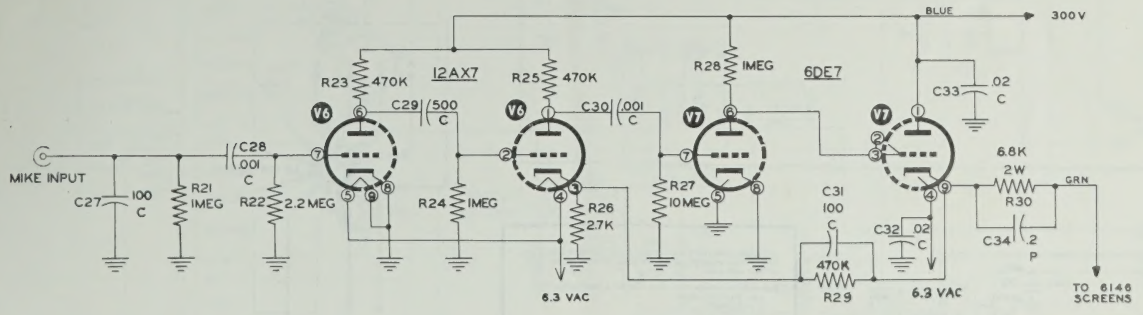
Link coupling is used on both bands by the use of a dual purpose link. A one turn coil in the center of the hairpin loop couples into the center of the 6-meter tank coil, and the hairpin loop coupling to the end of the tuned lines. The RF output is fed to a coaxial jack on the rear apron of the Transmitter and a 75 mmf variable capacitor connected between the link and ground tunes out any reactance that may be present.

MODULATOR

A 12AX7 tube is used as a high gain two stage resistance coupled speech amplifier. The output of the speech amplifier is coupled to the 6DE7 through a low capacity coupling capacitor (C-30). This low capacity coupling, along with the 470 K resistor (R-27) and 100 mmf capacitor (C-31) which forms the feedback circuit from the modulator cathode back to the speech amplifier cathode, shapes the response to favor the voice frequencies, thus allowing a higher average level to be maintained where it will be the most effective.

The audio energy from the speech amplifier is coupled to the grid of one triode section of a 6DE7. This tube contains two dissimilar triode sections. One triode section is rated at 1.5 watts dissipation and the other at 7 watts dissipation. The lower rated triode is used as a direct coupled driver, its plate being tied to the control grid of the heavier duty triode which forms the modulator. This second triode is biased sufficiently to limit its conduction and therefore the screen voltage on the final is of a low value, which results in a low resting carrier.

With modulation the conduction of the heavy duty triode section is varied in accordance with the average voice level. This gives a controlled carrier effect by varying the screen voltage on the 6146 tubes, at the same time the audio signal is superimposed on this variable voltage. The net result is to produce a carrier output which increases with the percentage of modulation applied.



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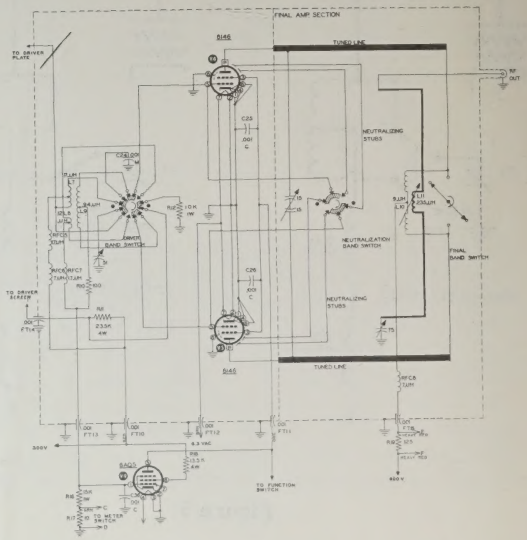
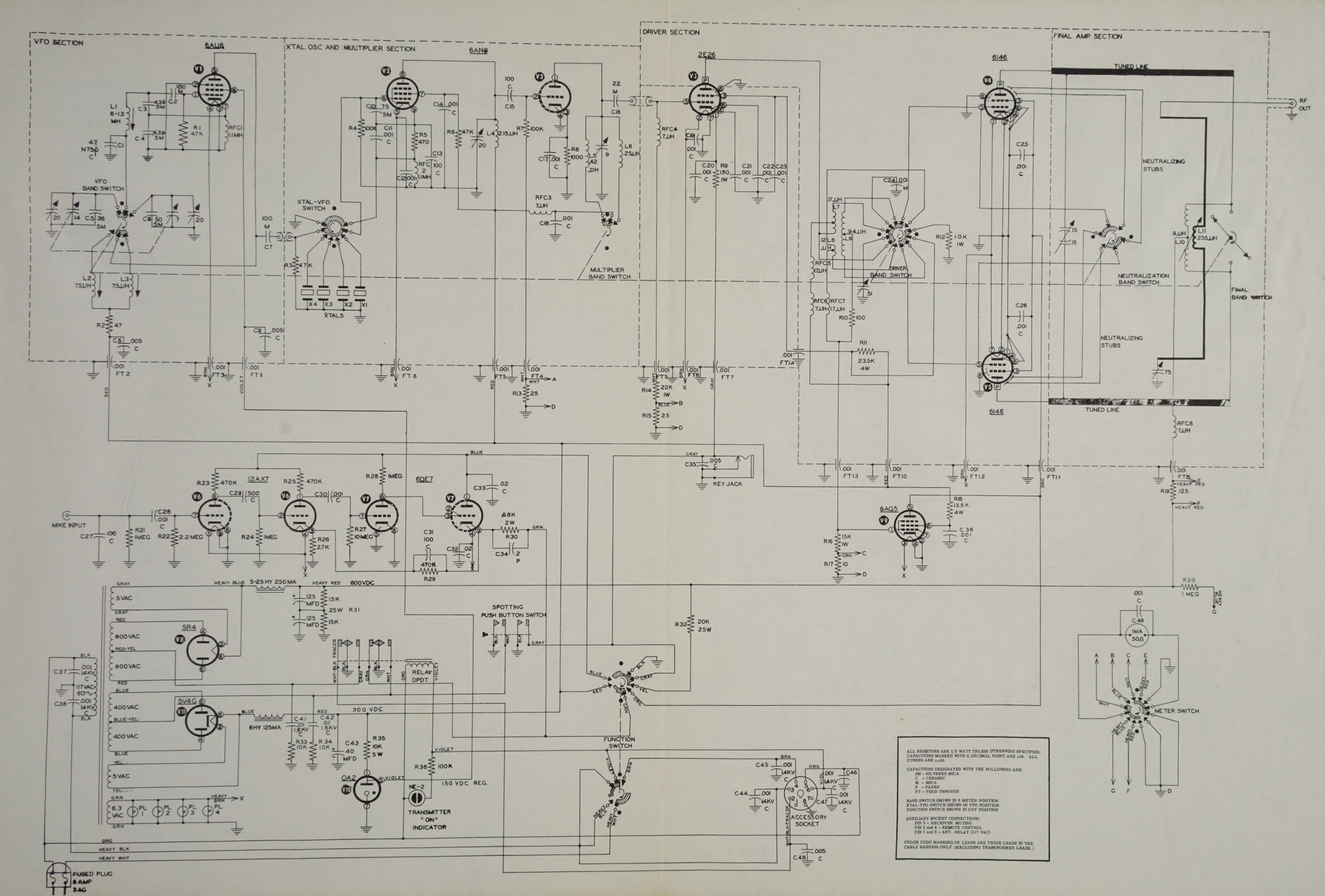


Figure 7


VFO SECTION
6AU6
XTAL OSC AND MULTIPLIER SECTION
6AN8
DRIVER SECTION
2E26
FINAL AMP SECTION
6146
TUNED LINE
RF OUT
NEUTRALIZING STUBS
NEUTRALIZATION BAND SWITCH
FINAL BAND SWITCH
VFO BAND SWITCH
XTAL-VFO SWITCH
XTALS
MULTIPLIER BAND SWITCH
DRIVER BAND SWITCH
KEY JACK
MIKE INPUT
12AX7
6DE7
6AQ5
SPOTTING PUSH BUTTON SWITCH
RELAY DPDT
5R4
5V4G
800VDC
300 VDC
150 VDC REG.
6HY 125MA
5-25HY 250MA
FUNCTION SWITCH
ACCESSORY SOCKET
METER SWITCH
TRANSMITTER "ON" INDICATOR
FUSED PLUG 8 AMP 3AG
ALL RESISTORS ARE 1/2 WATT UNLESS OTHERWISE SPECIFIED. CAPACITORS MARKED WITH A DECIMAL POINT ARE μfd. ALL OTHERS ARE μμfd.
CAPACITORS DESIGNATED WITH THE FOLLOWING ARE:
SM = SILVERED MICA
C = CERAMIC
M = MICA
P = PAPER
FT = FEED THROUGH
BAND SWITCH SHOWN IN 6 METER POSITION
XTAL-VFO SWITCH SHOWN IN VFO POSITION
FUNCTION SWITCH SHOWN IN OFF POSITION
AUXILIARY SOCKET CONNECTIONS:
PIN 2 = RECEIVER MUTING
PIN 3 and 4 = REMOTE CONTROL
PIN 5 and 6 = ANT. RELAY (117 VAC)
COLOR CODE MARKING OF LEADS ARE THOSE LEADS IN THE CABLE HARNESS ONLY. (EXCLUDING TRANSFORMER LEADS.)

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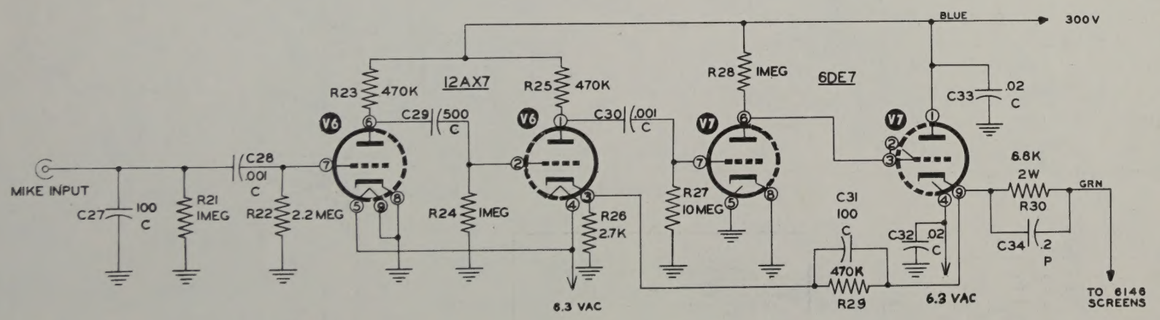


Figure 8

POWER SUPPLIES

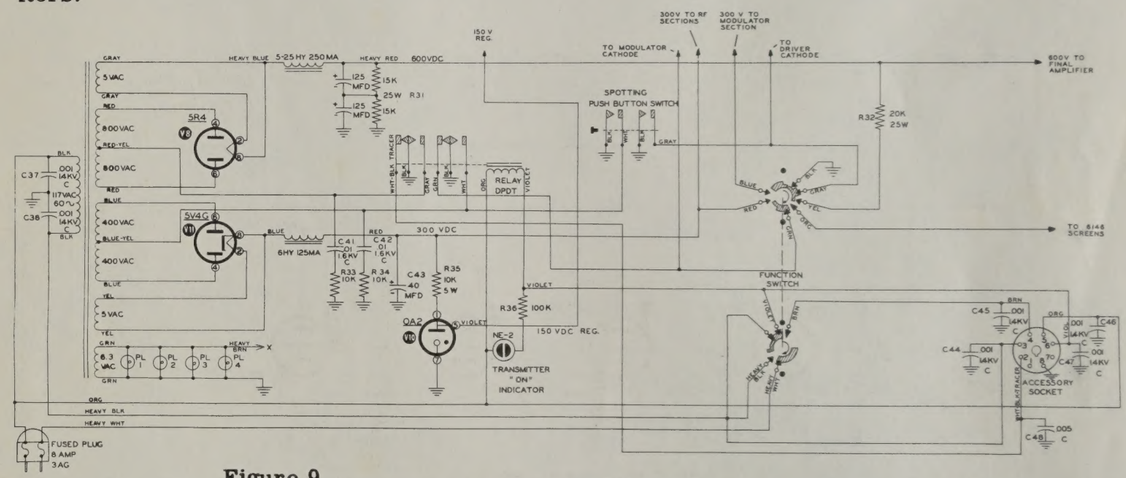
A single transformer is utilized for both the high voltage and low voltage power supplies. It also contains all of the filament windings.

The low voltage supply uses a 5V4G rectifier with a choke input filter which delivers 300 volts at 125 ma to the modulator and all RF sections, except the final amplifier.

The high voltage supply consists of a 5R4GY rectifier, choke input filter, two 125 mfd electrolytic capacitors in series, and a center-tapped bleeder resistor which also balances the series capacitors.

The two 125 mfd 450 volt electrolytic capacitors connected in series result in a filter capacity of 62.5 mfd at 900 volts, offering sufficient capacity for good dynamic regulation under varying load conditions and a good safety factor on voltage breakdown. The use of paper or oil capacitors becomes impractical at these values of capacity. The supply delivers 600 volts at 250 ma to the plates of the final amplifier.

Both sides of the AC line are fused in a special line plug and all circuits entering or leaving the transmitter chassis with 117 volts AC on them are bypassed with special AC line bypass capacitors.



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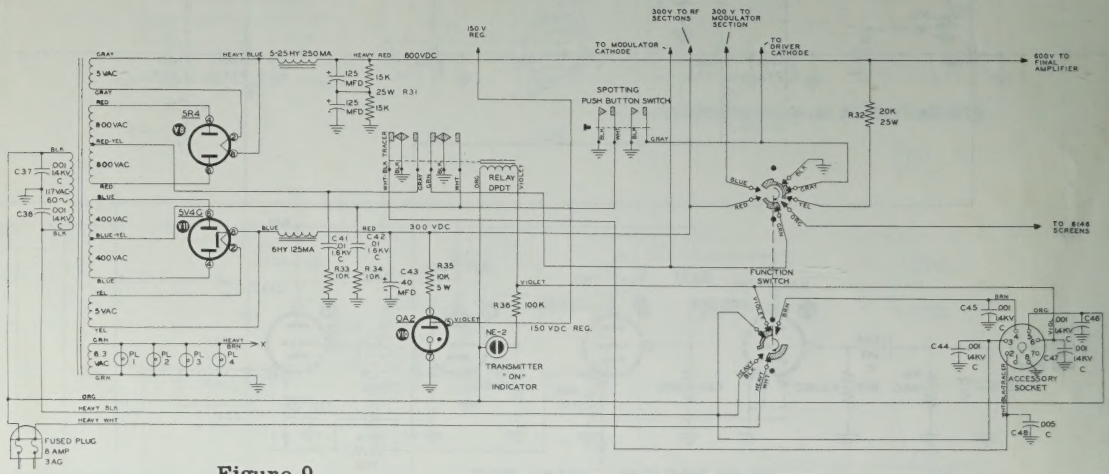

Figure 9